

Ch 471 EXAM #1 OUTLINE
Winter 2007

NOTE: Use this outline at your own risk – sometimes a topic is omitted that you are still responsible for. It is meant to be a study aid and is not meant to be a replacement for actually reviewing the lecture notes and homework assignments.

Electronics

- Ohm's Law $V = iR$
- series and parallel equivalent resistance
- voltage divider circuit
- RC circuits, $f_c = 1/(2\pi RC)$, low and high pass filters
- golden rules of operational amplifier circuits
- non-inverting amplifier circuit, gain = $(R_1+R_2)/R_1$
- inverting amplifier circuit, gain = $-R_2/R_1$
- integrator and differentiator circuits
- current to voltage converter circuit

Introduction

- PC Architecture - CPU, memory, data bus, I/O channels, registers
- Binary vs. decimal numbers - binary addition/subtraction

Digital to Analog Converters

- binary weighted resistor D/A
- R-2R network D/A
- Operating characteristics - speed, resolution

Analog to Digital Converters

- successive approximation A/D
- operating characteristics - sampling rate, resolution, gain, MUX

Noise Detection and Reduction Techniques

- Signal to Noise ratio
- frequency content of noise, white noise
- types of noise – thermal or Johnson noise; shot noise; A/D quantization noise and calculating quantization error
- how to experimentally discriminate between shot and constant noise
- external noise, shielding, ground loops, cables
- Removing Noise in Hardware - RC filters, signal averaging using digitizing oscilloscopes
- The effect of instrumental noise on precision of analyses – derived using Beer's Law, propagation of errors, relative standard deviation, advantages of shot noise limited detectors
- Removing Noise in Software
 - Finite Impulse Response (FIR) Filters using smoothing coefficients in a spreadsheet
 - Moving Average filter
 - Savitzky-Golay filter
 - Finite Impulse Response (FIR) Filters using Fourier Transforms and Convolution
 - Definition of the Fourier Transform
 - inverse transform, transform pairs, phase term, and magnitude or power spectrum
 - Definition of Convolution
 - Commutative, associative, distributive and area preservation properties
 - Two useful convolution theorems
 - Digital Filters – Moving Average and Savitzky-Golay filters using convolution
 - Infinite Impulse Response (IIR) Filters
 - Butterworth
 - Chebyshev
 - Operating characteristics of each filter

Instrumental Applications of Convolution

- Brief instrumental examples – monochromator resolution; photomultiplier tube response to fast transient signals
- Sampling Theory – Impulse function, Nyquist Criteria, Aliasing (“Folding”)
- Apodization
 - FTIR basics – Michelson Interferometer, Fourier Transformation to obtain FTIR spectrum
 - Effects of boxcar vs. triangular windows; other windows such as Hanning and Parzen